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SYLLABUS 29

Contribution from the States Relations Service
A. C. TRUE, Director

In Cooperation with the Office of Public Roads
and Rural Engineering
L. W. PAGE, Director

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ILLUSTRATED LECTURE ON
PUBLIC-ROAD IMPROVEMENT

Prepared in the
Office of Public Roads and
Rural Engineering

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U. S. DEPARTMENT OF AGRICULTURE,

STATES RELATIONS SERVICE.

A. C. TRUE, Director.

In cooperation with the Office of Public Roads and Rural Engineering, L. W. Page, Director.

SYLLABUS 29—ILLUSTRATED LECTURE ON PUBLIC-ROAD IMPROVEMENT.¹

Prepared in the Office of Public Roads and Rural Engineering.

INTRODUCTION.

View.

The subject of public-road improvement presents a multitude of important phases which could hardly be covered completely, even in a textbook of large proportions, much less in a single address of reasonable length. The present purpose, therefore, is to consider only the general features of the subject, without attempting to discuss technical details which would be of interest to comparatively few besides those actually engaged in road-improvement work.

Public roads serve very much the same purpose in a community that stairways and corridors serve in a building, and a progressive community should feel as much interest in securing commodious and serviceable roads as a progressive family feels in securing these qualities for the stairways and corridors of the dwelling which it occupies. Mud roads, such as are found in many localities, correspond in appearance to the ladders in a barn. But the analogy goes no further than appearance, because no intelligent farmer would continue to employ ladders in his barn if some other device could be more economically used in transporting commodities between its different stories. The fact that one bale of cotton is a heavy wagonload on the mud roads in some of the States, while on improved roads eight bales can be drawn easily by two horses, disqualifies the mud road for the latter class.

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¹This syllabus has been prepared in the Office of Public Roads and Rural Engineering at the request of J. M. Stedman, Farmers' Institute Specialist of the States Relation Service, and is designed to aid farmers' institute lecturers and other extension lecturers in presenting the subject before popular audiences. The syllabus is illustrated with 60 lantern slides. The numbers in the margins of the pages refer to the lantern slides as listed in the Appendix.

View.

This same contrast would hold, of course, for corn, wheat, oats, potatoes, and hay, as well as cotton, and when it is considered that in 1915 the aggregate weight of all these crops in the United States amounted to some 270,000,000 tons and that the average length of wagon haul was certainly several miles, the importance of being able to haul heavy loads may be appreciated.

- 4 Aside from all questions of saving in the cost of transporting farm products, however, improved roads afford cultural advantages which frequently are considered ample compensation for the entire cost of their improvement. Poor roads, 5 poor schools, ignorance, and poverty usually are very closely 6 associated; while good roads, consolidated schools, attractive homes, and a spirit of sympathetic cooperation among neighbors are all usually found in the same community. This does 7 not mean, of course, that good roads alone would serve to correct all shortcomings, because the character of its people is what really determines the standing of every community. 8 But there is no one agency which contributes more toward the advancement of mankind than social intercourse, and the 9 success of this agency in rural communities is certainly dependent in a great measure upon the condition of the roads. There is small wonder, then, that public-road improvement is a fixed and continuous policy of all civilized nations and that public sentiment, which is largely controlled by intelligent farmers, is in almost complete accord with this policy.

THE ROAD PROBLEM ANALYZED.

The public-road problem, as encountered in most communities, presents three distinct phases. The first is concerned with public sentiment, or the kind of accommodation in the way of public roads which the public demands; the second with finance, or how to raise funds to pay for the road accommodations desired; and the third with highway engineering, or how to expend the road funds so as to secure the greatest good for the greatest number.

PUBLIC SENTIMENT.

The first phase of the problem can not be determined exactly, because public sentiment is constantly changing. But, judging from experience, it usually is safe to assume that the taxpayers in a community will eventually demand a system of roads which affords farmers an opportunity to market their produce economically and provides for everybody a means

of comfortable travel at all seasons. In order that road funds may be economically expended, therefore, such a system should be planned before any extensive work of road improvement is undertaken. Few people who have never studied a road map realize what a network of roads is required to serve the public, or how carefully the distribution of population and industries must be studied in order to determine the relative importance of the different roads.

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FINANCE.

Usually the question of financing road improvement is concerned with deciding, first, how much money is needed, and, second, whether it shall be raised by the sale of bonds or by direct taxation. A road map which shows, in addition to the roads, the distribution of population and industries and available road-building materials, affords a fair basis for planning a system of improved roads as well as for making a rough estimate of construction costs. After the amount of money required has been estimated, the matter of interest rates should be a considerable factor in determining whether the funds shall be raised by means of bonds or by direct taxation. Whatever method of financing road construction may be adopted, the funds for maintenance should be raised by direct taxation, and ample provision for this item should always be included in the plan of finance.

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ENGINEERING.

By studying a map of the average county, it will be seen that the public roads vary to such an extent in degree of importance that they should be divided into at least three or four classes, according to the traffic which they probably will accommodate after improvement. It is apparent also that a highly improved road under concentrated traffic might afford no better accommodation than a well-graded earth road under traffic consisting of only an occasional vehicle.

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Now, when it is considered that there are at least seven well-recognized types of road surface, any of which may be economically employed under certain conditions, no argument should be required to establish the fact that planning public-road systems and determining the proper types of improvement for individual roads are problems which should be solved by a skilled and experienced engineer if satisfactory results are to be secured. The first duty of the public, therefore, is to see that the officials in charge of road work are

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View.

- fitted for the positions they hold and that the organization under which road work is supervised is sufficient to handle the work properly. Loose, inefficient county-road organizations have probably been responsible for more waste in the handling of road funds than all other causes combined. When the various officials in charge of road work are left to plan their own improvements, each man must usually learn by a series of mistakes how not to do things before he finally works out a fairly satisfactory system of procedure; while, if the organization were formed about one skilled county engineer as a nucleus, the experience gained in one section of the county would serve to lessen the chances of error in other sections. Furthermore, standardization of plans and methods ought to save much unnecessary duplication of work. In like manner, a well-organized State highway department, to which all county engineers are responsible, offers still further opportunity for standardization of methods and for reducing the number of preventable errors.
- It should be borne in mind constantly that the cost of insuring good work by means of adequate supervision is very small compared with the cost of replacing work that has failed. An expensive brick pavement that has been improperly designed or constructed may soon fail completely and become almost impassable, while a well-constructed and properly maintained earth road may last indefinitely. The only way to insure proper design and construction is by placing capable officials in charge of the work and providing them with an adequate organization.

LOCATION AND DESIGN.

In locating and designing roads there are a number of points to be decided which require very careful study in order properly to balance the convenience of travelers against the question of economy.

- For example, the question of whether a road should follow land lines or the location be otherwise influenced by property rights is a matter of very frequent consideration. To avoid unnecessary property damage is, of course, very desirable, but any considerable sacrifice of easy grades or directness in order to save a few acres of farm property is usually poor economy and not infrequently involves expensive changes in location after a road has already been improved. In locating or relocating a road, the guiding principles should be, first,

to have it convenient to those for whose use it is intended, and, second, to follow the lay of the land as closely as this can be done and at the same time accomplish the first purpose. Frequently in rugged country it is necessary to disregard land lines and cultivated fields altogether in order to keep the grades down to a reasonable maximum.

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The effect of steep grades in reducing the load which a horse can draw or in increasing the number of horses required to draw the same load is much greater than most people imagine. On a well-constructed earth road, for example, the load which one horse could draw on the level would require two horses on a 4 per cent grade, three horses on a 7.5 per cent grade, etc., and the better the surface the greater the effect of grades becomes. So it is evident that for economy in hauling the grades should be lower for a highly improved road than for one where the surface is less hard and smooth. The maximum grades are usually fixed at about 4 or 5 per cent (4 or 5 feet vertical rise in 100 feet measured horizontally) in rolling agricultural country and at from 6 to 8 per cent in mountainous regions.

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The danger from sharp curves is another point which deserves especial consideration and which automobiles have brought into prominence. For safety, all curves should be laid out so that a driver can see at least 200 or 300 feet ahead from any point on the road surface, and in cases where curves occur on steep grades this distance should preferably be increased. It is also desirable to widen the road surface on curves, because vehicles require more width of roadway when going around a curve than when going straight, and there is always a greater sense of security on the part of drivers when the roadway is widened to allow for the extra space occupied by vehicles. Elevating the outside of the roadway on curves is also practiced in some cases and serves as an added safeguard against accidents.

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The width of road surface required for single and double track roadways is another much-discussed point. It appears from such testimony as has been collected that 14 feet is about the minimum surface width required for two horse-drawn vehicles to pass safely and that a width of at least 16 feet and preferably 18 feet is required for automobiles. The width for single-track surfaces is made anywhere from 7 feet to 12 feet, but it seems that the 10-foot width is in most favor at present. No matter what width of surface may be employed, the total

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View.

width of roadway should be at least 20 feet and preferably not less than 24 feet. This provides for fairly wide shoulders on each side of the surface and makes maintenance easier than where a very narrow roadway is employed.

TYPES OF SURFACE.

- 24 A** Perhaps the question most frequently asked in connection with highway improvement is, "What type of road surface is the best?"
- 24 B** If this question could be answered offhand for every community, the road problem would be greatly simplified, and much of the highway engineer's work would be avoided. But, as already pointed out, there are at least seven
- 24 C** well-recognized types of construction, each of which is adapted to certain sets of conditions, and, in order to show how conditions should affect the selection, each type will be discussed briefly.

EARTH AND SAND-CLAY ROADS.

- 25** Of the 2½ million miles of public roads in the United States, earth roads constitute much the greater part. When well graded and drained and the soil conditions are favorable, such roads may prove satisfactory under moderate traffic for the
- 26** greater part of the year. Although earth roads require continuous maintenance, the method of maintaining them is very simple. A well-constructed road drag is the only implement required. Such drags may be made of a split log or of sawed
- 27** timber, and their cost should not exceed \$5 or \$6. The drag is usually operated by one man and a two-horse team, and the
- 28** dragging should be done after a rain, while the surface is still
- 29** sufficiently soft to be easily shaped.

- 30** When the soil is either very sandy or such as to become very
- 31** muddy when wet, the ordinary earth road is not usually satisfactory. A modified form of earth road which is adapted to conditions of this kind is made by supplying a surface composed of sand and clay mixed in proper proportions. Frequently it is possible to obtain natural-mixed sand-clay soil which is simply spread over the road and compacted by traffic,
- 32** but in other cases it is necessary to mix the materials on the road artificially. When the materials are of good quality, sand-clay roads are excellent for moderate traffic, especially
- 33** where the climate is favorable. They are maintained in the same way as ordinary earth roads.

GRAVEL ROADS.

Gravel is one of the most widely distributed road-building materials in the United States and is well adapted for use where the traffic is only moderate and largely horse drawn. There are roads in nearly every locality for which gravel is the ideal surfacing material. Well-constructed gravel roads are practically as good as macadam, and when good gravel can be obtained they are much cheaper to construct. They are also easy to maintain when the traffic is only moderate and frequently produce less dust than macadam roads.

MACADAM ROADS. --

Crushed stone has long been employed for road surfacing and, until the advent of the motor vehicle, was generally considered to be a most satisfactory road-building material.

Stone suitable for macadam construction occurs in great abundance in some sections of the country, but other sections are entirely devoid of such stone; and since the availability of suitable stone is necessarily a very important consideration in determining the practicability of employing this type of construction, it follows that the distribution of macadam roads in the country is very far from uniform. The Eastern States have an abundant supply of trap rock and limestone, and as a result have constructed a greater mileage of such roads than any other part of the country.

Rapid-going motor vehicles cause macadam roads to deteriorate rapidly, because the pneumatic tires force out the dust which binds the larger particles of stone together and thus produce raveling of the surface. Accordingly, in localities such as are found in New York and the New England States, where stone is the most readily available road-building material and where there are a great many motor vehicles, it has been found necessary to employ a modified form of macadam road, in which the particles of stone are held together by means of an artificial binder.

BITUMINOUS MACADAM ROADS.

It has been found that by filling the interstices between the stone particles of a macadamized surface with some bituminous material, such as tar or asphalt, the tendency to ravel under automobile traffic may be largely overcome. Two methods of applying the bituminous material are in common use. These are the penetration method, where the hot liquid is

View.
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View.

43 poured over the surface of the material before it is compacted and allowed to penetrate into the voids, and the mixing method, where the bituminous material is mixed with the stone before it is spread on the road.

44 When constructed of proper materials, bituminous macadam roads are very satisfactory for automobile traffic as well as for mixed traffic of autos and teams, but are not well adapted for team traffic alone. Notwithstanding the rather high maintenance cost usually connected with such roads, where materials suitable for their construction are readily available they are frequently more economical in the long run than any other type of construction.

CONCRETE ROADS.

45 In recent years Portland-cement concrete has been considerably used for road surfacing, and where good concrete materials are available surfaces of this material have proved economical for the main traveled roads. Wayne County, Mich., and Milwaukee County, Wis., have both constructed concrete roads on a large scale, and because of the road-material situation in each instance these two counties are undoubtedly justified in the selection of type which they have made.

46 Concrete for roads requires more carefully selected materials, a richer mixture, and much more careful curing than ordinary structural concrete. The reason for this is that the conditions to which it is subjected are comparatively very severe.

BRICK ROADS.

48 Where the traffic is very heavy and a good quality of vitrified paving brick may be secured at a reasonable cost it may be economical to employ them for country roads, even where other materials are readily available. Cuyahoga County, Ohio, in which the city of Cleveland is located, has constructed
49 a great many miles of brick pavement on concrete foundations, and, from all reports, is finding it economical and satisfactory. Brick pavements have also been extensively used in
50 the peninsula section of Florida, where other road-building materials are scarce. In the latter case the brick are laid directly upon a sand foundation, but this method of construction could hardly prove satisfactory where deep freezing occurs.

From the foregoing it is evident that in order to make a proper selection of surface type for any particular road all the

local conditions must be considered carefully. The character and amount of traffic, the kind of materials most readily available, and the amount of money available are all important considerations in the solution of this problem.

MAINTENANCE.

No matter what type of surface may be selected, the question of maintenance should come up for consideration as soon as the construction of a road is completed. All types of roads require frequent and careful attention if they are to deliver the maximum service for the money expended. The side ditches and culverts must not be allowed to become filled so as to interfere with proper drainage. Earth, sand clay, and gravel roads must be frequently patched and dragged. Macadam roads must be occasionally resurfaced, and for automobile traffic should preferably be given an annual surface treatment with some bituminous material and screenings, so as to keep down the dust and preserve the surface. Bituminous macadam must be frequently patched with bitumen and stone. The cracks and holes that develop in concrete pavements should be patched with tar and sand as soon as they form. The cracks in brick pavements should also receive immediate treatment, and the shoulders for all kinds of road surfaces should be kept free from weeds and should be reshaped whenever necessary.

The maintenance of public roads is so frequently neglected that in some instances road officials have felt justified in increasing the construction cost to a considerable extent in order to reduce, as far as possible, the necessity for maintenance. This practice is very poor economy, however, and there are few cases where a proper maintenance organization does not prove economical in the long run. The so-called patrol system of maintenance is perhaps best adapted to the needs of most communities. This system involves the employment of patrolmen and teams who go over the roads regularly and make small repairs of all kinds as soon as they are needed. It is extensively followed in France, as well as in several States of this country, and has in general proved satisfactory.

CONCLUSION.

In conclusion it is desired to call attention to a number of bulletins of the United States Office of Public Roads and Rural Engineering, copies of which may be obtained free of charge by applying to the Division of Publications, United States Department of Agriculture, Washington, D. C.

Farmers' Bulletin 338, Macadam Roads.

Farmers' Bulletin 597, The Road Drag and How It is Used.

Department Bulletin 249, Portland Cement Concrete for Country Roads.

Department Bulletin 373, Brick Roads.

Department Bulletin 463, Earth, Sand Clay, and Gravel Roads.

Office of Public Roads Bulletin 48, Repair and Maintenance of Roads.

APPENDIX.

LANTERN SLIDES.

No. of
view.

1. Poorly drained earth road, Maine, near Brunswick.
2. One bale of cotton on bad road, Jackson, Tenn.
3. Eight bales of cotton being drawn by two horses on good road in Madison County, Tenn. Old and new residences in background.
4. Poor roads, poor schools, ignorance, and poverty.
5. Consolidated school near Dinwiddie Court House on Boyden plank road. School built since road was improved. Dinwiddie Court House, Va.
6. School wagon hauls children to consolidated school at Dinwiddie Court House. Average number of children carried, 20; distance, 6 miles.
7. Up-to-date house and barn on good road leading into Ludington, Mich.
8. Trunk line, State highway, San Mateo County, Cal.
9. Trunk line, State highway, lined on both sides with beautiful Eucalyptus trees, San Mateo County, Cal.
10. Map showing typical plan for model highway system.
11. Map showing market-road system, Dinwiddie County, Va.
12. Map showing main market roads constructed under bond issue in Spottsylvania County, Va.
- 13 A. Typical cross sections for various road surfaces.
- 13 B. Typical cross sections for various road surfaces.
- 13 C. Typical cross sections for various road surfaces.
14. Chart showing inefficient county organization.
15. Chart showing efficient county organization.
16. Brick road near Zanesville, Ohio. Failure probably due to defective foundation.
17. A section of earth road, well graded and crowned with a smooth surface, and well drained, Kansas.
18. Mississippi post road, showing road conveniently located to farmhouse.
19. Relocation following contours. Sidehill construction, Allegheny County, Pa.
20. Chart showing the effects of grade and surface on tractive effort.
21. A typical grade crossing with steep grade and sharp turn. Two people were killed at this crossing on September 2, 1914.
22. Curve widened and elevated to bring the road to grade.
23. Chart showing double-track roadway.
- 24 A. Typical cross section of road surface.
- 24 B. Typical cross section of road surface.
- 24 C. Typical cross section of road surface.
25. Subdrain under construction, Montgomery County, Md.
26. Split-log drag.
27. Slab drag.
28. Earth road in Hardin County, Jackson Township, Iowa, before improvement.
29. Same road after dragging.
30. Typical sandy road near Eastover, S. C.

No. of
View.

31. Spreading clay on sand. Dry mixing, Nash County, N. C.
32. Mixing sand and clay with 18-inch disk harrow.
33. A sand-clay road near Pinehurst, N. C.
34. Gravel pit in Alexandria County, Va.
35. Spreading gravel on properly prepared foundation. Experimental road, Alexandria County, Va.
36. Gravel road near Baker City, Oreg.
37. Portable crushing outfit.
38. Maryland post road near Rockville. Applying screenings and rolling.
39. Automobile traveling at 80 miles an hour.
40. Macadam raveled on account of automobile traffic, Passaic County, N. J.
41. Constructing bituminous macadam road by the penetration method, Massachusetts.
42. Maine post road near Yarmouth, bituminous macadam penetration method. Second application of hot bitumen 350° F., $\frac{1}{2}$ gallon per square yard.
43. Bituminous macadam construction, mixing method, Jamaica, Queens County, N. Y.
44. Concrete road surfaced with bitumen, State highway, California.
45. Government experimental concrete road under construction near Chevy Chase, Md. Floating surface from "bridge."
46. Government experimental concrete road, Chevy Chase, Md., covering concrete with earth to prevent concrete from curing too rapidly.
47. Government experimental concrete road, Chevy Chase, Md.
48. Government experimental brick road, Chevy Chase, Md., concrete base.
49. Government experimental brick road, Chevy Chase, Md., applying cement grout.
50. Government experimental brick road, Chevy Chase, Md.
51. Side ditches filled with trash.
52. Dragging gravel road with steel drag, Westville, N. Y.
53. Surface treatment of macadam road with bituminous material and stone chips, Rockville pike, Md.
54. Patrolman patching depressions in a bituminous road, New York State road, Minaville, N. Y.
55. Cracks in concrete road patched with bitumen, Wayne County, Mich.
56. Road maintenance to be effective should include the cutting of weeds and grass by the roadside.

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10. Economic Survey of Eight Selected Counties. U. S. Dept. Agr. Bul. 393.

